# THE NATIONAL ELECTRICAL CODE AS IT AFFECTS METER OPERATIONS

The Twenty-fifth Short Course and Conference on Electric Meters
University of Florida - Gainesville, Florida
May 8-12, 1950

By
Thomas P. Branch
Power Utilization Specialist
Applications and Loans Division
Rural Electrification Administration
United States Department of Agriculture
Washington 25, D. C.

# THE NATIONAL ELECTRICAL CODE AS IT AFFECTS METER OPERATIONS

In general the problems involved are two in number:

1. Effective grounding and bonding, and
2. Adequate insulation.

## GROUNDING PURPOSES

The code states in section 2511:

> "Circuits are grounded for the purpose of limiting the voltage upon the circuit which might otherwise occur through exposure to lightning or other voltages higher than that for which the circuit is designed; or to limit the maximum potential to normal voltage."

and in section 2541:

> "Exposed conductive materials enclosing electrical equipment or forming a part of such equipment, are grounded for the purpose of preventing a potential above ground on the equipment."

These purposes of grounding may be stated in another way:

1. To limit or reduce potentials which might otherwise exist between conductors and equipment.
2. To limit the voltage between conductors and their metal enclosures, and
3. To provide a path for fault currents which may have sufficient magnitude to cause overcurrent devices to operate and de-energize the circuit.

We have long since recognized the fact that limiting potentials reduces the probability of electrical shock to persons or animals, and this point has been emphasized repeatedly. What has not been given proper recognition is that limiting or preventing potentials by grounding also reduces the possibility of insulation failures and arcing, thereby reducing any fire hazard from electrical causes.

## VOLTAGES

Ordinarily there are three sources of voltages for which protection must be provided:

1. Lightning
2. Distribution voltages of 2400 volts and above; and lastly
3. Secondary distribution voltages, usually 120-240 volt circuits.

When electric service first came into general use, very little consideration was given to more than electric lighting, the main reason for grounding secondary circuits was

for the purpose of reducing hazards resulting from primary voltages. Today since we have better transformers, transformer protection and decidedly improved line construction, faults which involve primary circuits are comparatively rare. On the other hand, present day usage of electrical appliances and high current consuming equipment has created a situation whereby protection from low-voltage faults has become the more important consideration. On the basis of the above stated conditions, and since the grounding and bonding required for low-voltage protection appears to be adequate for lightning and primary voltage protection, possibly we should discuss more in detail the requirements for low voltage protection.

Under the old requirements for grounding, that of having a grounding conductor and grounding electrode for secondary circuits and a similar but separate grounding arrangement for conduit or other metal enclosures of current-carrying equipment, many hazards developed. It has been found that at times when a fault ground existed between an energized conductor or part and grounded metal enclosure, the resistances of the separate grounds being relatively high, say 15 and 20 ohms respectively, there was not a sufficient current flow in the return through earth to rupture the overcurrent protection and clear the circuit. This condition permitted a potential to exist on exposed metal parts which might be injurious to persons and in most cases lethal to animals contacting such equipment while standing on the ground. Grounding installations made and maintained in accordance with rules set forth in the 1947 edition of the code should eliminate this condition. Service conductors (neutral in case of 3-wire services) which are required to be grounded, and non-current carrying parts of electrical equipment and the like, are required to be bonded or grounded to the same electrode. In this case a metallic path is provided for any fault currents to return through the service and short circuit conditions are developed. This short circuit condition has caused the over-current protection to operate and open the circuit in all such cases. Where there is still a momentary potential on this circuit between the occurrence of fault connection and the interrupting action of the over-current device, this rise in potential may reach one-half the secondary line voltage to ground where the resistance at the service ground is large as compared to the resistance of the electrode at the transformer.

The code recommends the use of continuous underground metallic water piping systems as the grounding electrode where such is available on the premises. This type of electrode has proved the best in urban areas. In rural areas, however, such local water distribution systems have, in many cases, been found to have high resistance paths to ground. Because of these occurrences, the Rural Electrification Administration has

recommended to its borrowers that artificial electrodes be required for grounding and that any water or other metallic underground piping system and well casings be bonded to these electrodes. Such grounding is recommended at the central yard meter pole and at each major building served. A sufficiently high percentage of rural water piping systems are so installed that a very high resistance ground is produced, hence this recommendation. In addition to this practice, in buildings housing live stock all metals such as stanchions, columns and wall siding which might be exposed to fault contact by current carrying parts of electrical wiring systems, and which may be contacted by persons or animals while standing on ground or grounded surfaces should be bonded by a good electrical conductor to the system grounding electrode at the building service.

All such grounding, and in addition the interconnection of all grounded secondary neutrals with a corresponding grounded primary system conductor, tends to reduce the resistance to ground for both systems. In most cases the grounding on primary systems has a lower resistance than grounds installed on the secondary circuits of transformers. This reduces the probability of lightning and faults on primary circuits having a serious effect on secondary equipment.

Based on the experiences of our borrowers in heavy lightning areas we now recommend that grounding for services be connected at the point where the meter loop receives its supply of current. That the grounding conductor be installed at least four (4) inches away from conduits or service cables leading to the meter base, and that such path to ground be not installed within nor immediately behind the meter base. That any metal enclosure for wires, such as conduit, be bonded to this grounding conductor at or near the service head. The metal enclosure or socket base for a meter is adequately grounded through bonded connection to the grounded steel conduit or raceway. This also grounds the meter base through metallic threads, etc.

The reasons for such grounding practices are obvious. Experience records indicate that ninety-five percent (95%) of all lightning surges produce impulse currents of less than 10,000 amperes. With ground resistances of from 5 ohm to 25 ohms the potential to ground may be from 50 M volts to 250 M volts. With a poor ground of as much as 100 ohms this potential may reach as high as one million volts. By installing a good path to ground away from the meter, the damaging effects to magnets and to insulations on coils have been reduced to a minimum. REA experience has shown also that in practically all cases of meter failure due to lightning, the resistance of the grounding electrode at the meter was lower than at the transformer.

The electrical industry and N. E. Code committees have continually endeavored to raise the standards for insulations on conductors. These have been improved and the old code grade rubber eliminated. Definite spacings are required between live parts of equipment and between live parts and grounded enclosures, ample wiring spaces, etc., maintained for listing or approval by Underwriters' Laboratories, Inc. These requirements are usually exacted for all equipments used in connection with wiring installations except meter bases and meters. Yet these equipments are in many cases attached to walls of insured buildings, most of them combustible.

Realizing that increasingly larger meter services will be necessary to supply the requirements of rural consumers, our borrowers in general require that meter loops supplying two or more buildings at one location, be located on a central yard pole. Also that each building receiving service from this central meter loop be supplied through a grounded service entrance installation as required by the National Electrical Code.

(Illustrated types of meter loops and building services as recommended may be found on pages 32 through 36 of the Form AL-5-R(1-15-50) copies of which have been distributed to you.) You will note the water pump motor service take-off is shown as being connected on the load side of the meter but on the line side of the meter service control equipment. This is permissible under the Code since this may provide service for water pumping in case of fire in a building served through the control equipment.

On these drawings you will note the inclusion of a circuit breaker which is known to our users as meter service control equipment. The devices have been produced by a number of manufacturers in accordance with specifications drawn up by our Technical Standards Division. They are designed to limit the amount of current which a consumer may use to the maximum safe capacity of the transformer serving the load. The over-current device is also designed to coordinate with any secondary over-current protection which might be installed on or within the transformer. Such protection serves many purposes:

1. It reduces probable transformer outages.
2. It reduces the necessity for service trips (often for great distances) by system employees to restore service. This is often the case even though self-protected transformers are used.
3. It also enables the user to restore his own service where the fault is in his own installation once the fault has been removed.
4. It acts in the capacity of a tell-tale device when continuous overloads indicate the need of a larger size meter loop and transformer. You will observe on the drawings illustrating meter loops, generally used by REA-financed system, the

inclusion of line and load conductors within the same metal conduit or raceway.

This arrangement has been criticised by many as being contrary to Code requirements. Our specialists, however, contended the Code was not involved. Consequently we applied to the Electrical Committee N. F. P. A. for an official ruling and received the following official interpretation no. 337, dated August 29, 1949:

> "STATEMENT: A 'Meter Loop' on a yard pole includes a service entrance circuit breaker on the load side of the meter and mounted in a suitable enclosure close to the meter. The building served from this yard pole equipment has in addition the service entrance equipment required by Article 230.
>
> "QUESTION: Does Section 2306 of the 1947 edition of the National Electrical Code forbid running the load side conductors to the top of the pole in the same raceway with the line side conductors to the meter?
>
> "ANSWER: No."

In summation, we should:

1. Provide adequate grounding and bonding against:
    a. Lightning surges
    b. Primary voltage failures, and
    c. Secondary voltage failures, especially follow-through action of secondary voltages after insulation failure caused by primary current flow in the secondary.
2. Keep insulation levels on meters and meter enclosures as high as possible.
3. Where the resistance to ground over primary grounding system is consistently higher than paths to ground on secondary service grounding installations, efforts must be made to improve conditions by lowering the ground resistance on primary systems. More or better grounds should be installed to attain lower resistance paths to ground. This removes the greater probability of failures occurring on consumer premises, especially metering equipment.